Preventive effects of purple potato in obesity and low-grade inflammation

Hua Zhang, Yuhuan Chen, Rong Tsao
Guelph Food Research Centre, AAFC
93 Stone Road W., Guelph, Ontario, Canada N1G 5C9
Alternative approach - food bioactives

(Adapted from Bhattacharyya et al.,(2014))
Chronic Diseases are the major cause of death

Chronic diseases include heart disease, stroke, cancer, chronic respiratory diseases and diabetes. Visual impairment and blindness, hearing impairment and deafness, oral diseases and genetic disorders are other chronic conditions that account for a substantial portion of the global burden of disease.

From a projected total of 58 million deaths from all causes in 2005, it is estimated that chronic diseases will account for 35 million, which is double the number of deaths from all infectious diseases (including HIV/AIDS, tuberculosis and malaria), maternal and perinatal conditions, and nutritional deficiencies combined.

35 000 000 people will die from chronic diseases in 2005

<table>
<thead>
<tr>
<th>Cause</th>
<th>Deaths</th>
</tr>
</thead>
<tbody>
<tr>
<td>HIV/AIDS</td>
<td>2 630 000</td>
</tr>
<tr>
<td>Tuberculosis</td>
<td>1 007 000</td>
</tr>
<tr>
<td>Malaria</td>
<td>883 000</td>
</tr>
<tr>
<td>Cardiovascular</td>
<td>17 528 000</td>
</tr>
<tr>
<td>Cancer</td>
<td>7 586 000</td>
</tr>
<tr>
<td>Chronic respiratory</td>
<td>4 676 000</td>
</tr>
<tr>
<td>Diabetes</td>
<td>1 225 000</td>
</tr>
</tbody>
</table>

60% of all deaths are due to chronic diseases

**UNDERLYING SOCIOECONOMIC, CULTURAL, POLITICAL AND ENVIRONMENTAL DETERMINANTS**
- Globalization
- Urbanization
- Population ageing

**COMMON MODIFIABLE RISK FACTORS**
- Unhealthy diet
- Physical inactivity
- Tobacco use

**INTERMEDIATE RISK FACTORS**
- Raised blood pressure
- Raised blood glucose
- Abnormal blood lipids
- Overweight/obesity

**MAIN CHRONIC DISEASES**
- Heart disease
- Stroke
- Cancer
- Chronic respiratory diseases
- Diabetes

http://www.who.int/chp/chronic_disease_report/full_report.pdf Accessed March 5, 2018
Diet and chronic disease prevention

**HEALTH CARE COST SAVINGS**

**Dietary Supplements** for Smart Prevention

A new economic report shows that taking specific dietary supplements can provide significant individual and societal healthcare savings, by reducing the number of hospitalizations and other costly medical events associated with chronic diseases. The report looked at eight dietary supplement regimens and four conditions in a targeted population of U.S. adults 55+ who have the specific conditions or are at high risk for the disease.

### Supplements as interventions

Taking any of these eight dietary supplements at preventive intake levels* has been shown to reduce the occurrence of medical events related to these four diseases in high-risk populations.

#### Event rate

<table>
<thead>
<tr>
<th>Disease</th>
<th>Event Rate</th>
</tr>
</thead>
<tbody>
<tr>
<td>Coronary heart disease</td>
<td>16%</td>
</tr>
<tr>
<td>Diabetes &amp; CHD</td>
<td>12%</td>
</tr>
<tr>
<td>Age-related eye disease</td>
<td>33%</td>
</tr>
<tr>
<td>Osteoporosis**</td>
<td>15%</td>
</tr>
</tbody>
</table>

*Source: Centers for Disease Control and Prevention

#### Relative risk reduction

<table>
<thead>
<tr>
<th>Condition</th>
<th>Relative Risk Reduction</th>
</tr>
</thead>
<tbody>
<tr>
<td>Coronary heart disease</td>
<td>3.3% to 11.5%</td>
</tr>
<tr>
<td>Diabetes &amp; CHD</td>
<td>10.2%</td>
</tr>
<tr>
<td>Age-related eye disease</td>
<td>23.0%</td>
</tr>
<tr>
<td>Cataracts</td>
<td>15.3% to 18.6%</td>
</tr>
</tbody>
</table>

### 2013–2020 Cumulative Stats

**Medical events avoided**

The number of medical events avoided between 2013–2020 if the targeted population used these supplements at preventive intake levels:

- 808,000 to 2,337,000
- 650,000
- 7,659,000
- 548,000 to 1,208,000

**Avoided expenditures**

- $12.1 – $35.1 billion
- $9.8 billion
- $31.0 billion
- $6.8 – $15.0 billion

**Net savings**

- $3.9 – $26.6 billion
- $7.8 billion
- $7.7 billion
- $4.8 – $12.2 billion

**Savings yet to be realized**

- $2.8 – $26.5 billion
- $7.8 billion
- $7.4 billion
- $4.2 – $8.6 billion

*Notes: Preventive intake levels identified in full report. **Dietary supplement regimens for osteoporosis apply only to women 55+ and over. ***With less than 1% currently using this supplement, nearly all of the net savings has yet to be realized. Source: Smart Prevention – Health Care Cost Savings Resulting from the Targeted Use of Dietary Supplements – Frost & Sullivan: www.frost.com

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Antioxidant capacity (ORAC) of 12 potato cultivars

Cultivar

Purple-majesty
Mackintosh-black
Red-thumb
Y38
Chieftain
Nordonna
F04038
Norland
Yukon-gold
Banana
Sangre
Snowden

Antioxidant Capacity (ORAC)

High antioxidant content and activity

<table>
<thead>
<tr>
<th>Anthocyanins</th>
<th>PPE</th>
<th>mg/100g DW</th>
</tr>
</thead>
<tbody>
<tr>
<td>1 pelargonidin</td>
<td>2.88 ± 0.01</td>
<td></td>
</tr>
<tr>
<td>2 petunidin</td>
<td>15.27 ± 1.72</td>
<td></td>
</tr>
<tr>
<td>3 malvidin</td>
<td>1.84 ± 0.04</td>
<td></td>
</tr>
<tr>
<td>TAC</td>
<td>39.0 ± 0.03</td>
<td></td>
</tr>
</tbody>
</table>
Molecular docking of purple carrot or potato derived anthocyanins to SGLT1 or GLUT2

Zhang et al. Mol Nutr Food Res. 2017
Animal model of low-grade inflammation and obesity

HFD/LPS intervention

400 μg/kg BW oral delivery drinking water

10 or 100 mg/kg BW anthocyanin-rich purple potato extracts (PPE) by oral gavage

Mouse model:
16 weeks old female C-57Bl-6
12 mice/group

Diet:
Normal diet (14% protein) and high fat diet

Oral Drinking water

Animal groups: Negative control (NCN), PPE-HFD (NC), Positive control/HFD/LPS (PC/HFD), PPE-Low/HFD/LPS (PPL), PPE-High/HFD/LPS (PPH)

During trial
Body weight – Weekly
Food Consumption – Weekly
Presence of endotoxin in blood
Blood glucose-ENDPOINT
Effect of purple potato-derived anthocyanins on obesity

Zhang et al. 2018

Body weight

Blood glucose

Insulin (ng/mL)
Effect of purple potato-derived anthocyanins on blood lipid profile

Zhang et al. 2018
Effect of purple potato-derived anthocyanins on gut leaking (plasma D-mannitol & endotoxin)

Andoh A. 2016. Digestion; 93: 176-181

Zhang et al. 2018
Purple potato extracts reduce systemic inflammation

Zhang et al. 2018
Purple potato extracts prevent inflammation in White adipose tissue (WAT)
Effect of purple potato-derived anthocyanins on gut integrity and immune responses

<table>
<thead>
<tr>
<th>Jejunum</th>
<th></th>
<th>HFD</th>
<th>HFD/LPS</th>
<th>LPP</th>
<th>HPP</th>
</tr>
</thead>
<tbody>
<tr>
<td>ZO-1</td>
<td>136.0±28.68a</td>
<td>1.32±0.42b</td>
<td>0.73±0.28b</td>
<td>48.21±13.11a</td>
<td>155.54±31.39a</td>
</tr>
<tr>
<td>JAMA</td>
<td>194.0±14.49a</td>
<td>2.15±0.86b</td>
<td>1.36±0.64b</td>
<td>164.23±22.17a</td>
<td>195.80±44.19a</td>
</tr>
<tr>
<td>Claudin3</td>
<td>4.15±0.70a</td>
<td>1.26±0.35b</td>
<td>1.14±0.28b</td>
<td>1.96±0.30b</td>
<td>2.22±0.31b</td>
</tr>
</tbody>
</table>

- Colonic barrier & immune dysfunction

<table>
<thead>
<tr>
<th>Colon</th>
<th></th>
<th>HFD</th>
<th>HFD/LPS</th>
<th>LPP</th>
<th>HPP</th>
</tr>
</thead>
<tbody>
<tr>
<td>ZO-1</td>
<td>7.69±1.38a</td>
<td>1.30±0.41b</td>
<td>2.5±0.81b</td>
<td>5.61±1.05a</td>
<td>7.51±1.64a</td>
</tr>
<tr>
<td>JAMA</td>
<td>1.57±0.15a</td>
<td>0.91±0.09b</td>
<td>0.97±0.05b</td>
<td>1.19±0.2</td>
<td>1.69±0.11a</td>
</tr>
<tr>
<td>Claudin1</td>
<td>3.56±0.49a</td>
<td>0.98±0.32b</td>
<td>1.31±0.06b</td>
<td>3.05±0.71a</td>
<td>3.38±0.64a</td>
</tr>
<tr>
<td>Claudin3</td>
<td>3.62±0.44a</td>
<td>1.56±0.37a</td>
<td>1.22±0.24b</td>
<td>2.71±0.42a</td>
<td>2.78±0.65a</td>
</tr>
<tr>
<td>Occludin</td>
<td>6.97±1.05a</td>
<td>1.80±0.5b</td>
<td>1.38±0.33b</td>
<td>4.27±1.0b</td>
<td>6.11±0.82a</td>
</tr>
<tr>
<td>Muc2</td>
<td>1.13±0.2</td>
<td>0.93±0.34</td>
<td>0.85±0.21</td>
<td>0.74±0.17</td>
<td>1.52±0.32</td>
</tr>
<tr>
<td>MCP-1</td>
<td>1.37±0.38a</td>
<td>1.22±0.12a</td>
<td>3.04±0.66b</td>
<td>0.42±0.19a</td>
<td>0.5±0.16a</td>
</tr>
<tr>
<td>TNF-α</td>
<td>1.06±0.13a</td>
<td>2.19±0.38a</td>
<td>3.72±0.93b</td>
<td>1.59±0.31a</td>
<td>0.87±0.37a</td>
</tr>
<tr>
<td>IL-6</td>
<td>1.21±0.33a</td>
<td>6.21±1.9b</td>
<td>7.38±1.8b</td>
<td>3.36±2.35a</td>
<td>1.62±0.64a</td>
</tr>
<tr>
<td>IL-1β</td>
<td>1.09±0.22a</td>
<td>41.18±12.54b</td>
<td>35.7±9.64b</td>
<td>8.30±1.82a</td>
<td>8.26±1.83a</td>
</tr>
<tr>
<td>IL-17A</td>
<td>1.25±0.31a</td>
<td>34.25±19.00b</td>
<td>111.17±28.05b</td>
<td>31.54±25.52a</td>
<td>15.43±4.16a</td>
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<tr>
<td>IL-10</td>
<td>1.6±0.28a</td>
<td>0.41±0.09b</td>
<td>0.146±0.08b</td>
<td>0.27±0.24b</td>
<td>1.09±0.25a</td>
</tr>
</tbody>
</table>
Purple potato extracts modulate gut sensing homeostasis
Implication of dietary purple potato extracts on integrity gut homeostasis

- Restore gut integrity
- Restore immune homeostasis
- Restore blood glucose level
- Change blood lipid profile
- Prevent systemic inflammation

Adapted from: Ha et al. 2014, World J Gastroenterol. 24: 16498-517
Purple potato extracts regulate metabolic pathway
Purple potato extracts modulate fecal SCFA and BCFA distribution

Acedic acid

Propionic acid

Butyric acid

Isobutyric acid

Isovaleric acid
Purple potato extracts changes gut microbiota composition

α-diversity

Microbiota taxa composition at the phylum level
Purple potato extracts regulate gut microbiota

Diagram showing the abundance of various bacterial species across different treatments.
Prebiotic effects of purple potato extracts

PPE supplementation promotes the growth of *Parabacteroides distasonis*, resulting in alleviation of obesity and metabolic dysfunction.  

Adapted from Wang et al. 2019. Cell Reports, 26, 222-235
• Anthocyanins derived from purple potatoes showed promising antioxidant activity and bioaccessibility *in vitro*.

• Supplementation of anthocyanin-rich extracts from purple potatoes prevented high fat-diet and endotoxin induced obesity and reversed inflammatory tone.

• Dietary purple potatoes derived anthocyanins regulate the interplay of metabolites, microbiota and gut sensing ability, leading to maintaining gut barrier functionality and mucosal immune homeostasis.

• Continued effort in breeding highly pigmented potato varieties such as anthocyanin-rich ones will provide additional source of healthy food and feed resource.
Acknowledgment

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Thank you!